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Control system of Dahlander Motor using Programmable Logic Controller based on Human Machine Interface and Internet of Things

Zikri Alwi[1], Muldi Yuhendri [1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

The Dahlander motor is a three-phase induction motor capable of operating at two distinct rotational speeds by altering the stator winding configuration between star (Y) and delta (Δ). This dual-speed feature is essential for industrial machines such as cranes, lathes, and conveyors that require variable speed operation. However, conventional manual control methods are still widely used, posing risks to operational efficiency and safety. This study presents the design and implementation of an automated control system for a 1.3 kW Dahlander motor using a Siemens S7-1200 Programmable Logic Controller (PLC), a KTP 700 Comfort Human Machine Interface (HMI), and an Internet of Things (IoT) platform based on Node-RED. The system supports remote control via HMI panels, personal computers, and smartphones through a web-based interface using the Profinet protocol. The control logic is developed in the TIA Portal environment, enabling selection between low-speed and high-speed modes. Experimental results demonstrate that the system effectively controls motor speed with accurate and stable operation. The integration of HMI and IoT provides real-time remote monitoring and control capabilities, enhancing operational reliability and minimizing human error. This integrated system offers a cost-effective and adaptive solution for local industries, especially small and medium-sized enterprises, to embrace Industry 4.0 technologies.

Corresponding Author:

Zikri Alwi
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: zikrialwi703@gmail.com

1. INTRODUCTION

Electric motors play an important role in supporting industrial automation systems due to their high efficiency and reliability in driving mechanical loads. One type of motor that is widely used in industry is the Dahlander motor, a three-phase induction motor with two-speed capability by changing the number of poles in the stator winding. This change is made by modifying the connection configuration between the star (Y) and delta (Δ) windings, resulting in a speed ratio of 2:1 [1]. This uniqueness makes the Dahlander motor ideal for applications such as lathes, cranes, and conveyors that require operation at two speeds. However, in many industrial installations, the operation of the Dahlander motor is still done manually using conventional switches or contactors [2]. This causes a number of problems, such as the high risk of human error, slow switching times, and the potential for mechanical failure or overheating due to untimely load shifting [3],[4]. Reliance on manual methods also reduces operational efficiency, especially in production scenarios that require dynamic response and real-time control [5] .

In the context of the Industrial Revolution 4.0, various technologies such as Programmable Logic Controller (PLC), Human Machine Interface (HMI), and Internet of Things (IoT) have shown great potential in improving the performance of industrial control systems automatically, integrated, and based on data [6]-

[8]. Previous studies have shown that PLC is very reliable in sequential control, while HMI is able to improve user interaction with the system visually and intuitively. IoT, on the other hand, enables flexible and real-time remote monitoring and control [9]. The application of the IoT architecture concept that includes the perception, transportation, application, and user layers has also proven effective in automatic monitoring and control systems in various fields, including smart agriculture [10]-[12].

This study proposes a Dahlander motor control system solution based on Siemens S7-1200 PLC integrated with Simatic KTP700 Comfort HMI and IoT interface using Node-RED. This system not only allows automatic switching between two motor speeds, but also provides real-time visualization of system status via HMI and remote control access via smartphone or computer via internet network. The system design is done using TIA Portal platform for PLC programming and HMI design, while Node-RED is used to build IoT interface connected to internal web server. The main innovation of this study is the development of an integrated control system based on PLC-HMI-IoT for Dahlander motor, which is still very rarely implemented locally, especially in small-medium industrial scale. This system comprehensively answers the challenges of efficiency, reliability, and flexibility of dual-speed motor control. In addition, this solution also encourages the adoption of more affordable and adaptive automation technology for domestic industry players, so as to strengthen competitiveness and technological independence in the digital era.

2. METHOD

This study designed a 2-speed control system for Dahlander motor rotation using HMI and IoT-based PLC, which is basically a detailed and specific plan for controlling the Dahlander motor that can be controlled using an interface, with the aim of making it easier for users to control the Dahlander motor when it is operated. The design of this tool is carried out to create a fast and slow rotation control system that can be controlled directly using an HMI and IoT-based PLC. To facilitate the process of designing tools and analysis by making the block diagram as a reference for the work of the block diagram system of this tool which will be made as in Figure 1 below.

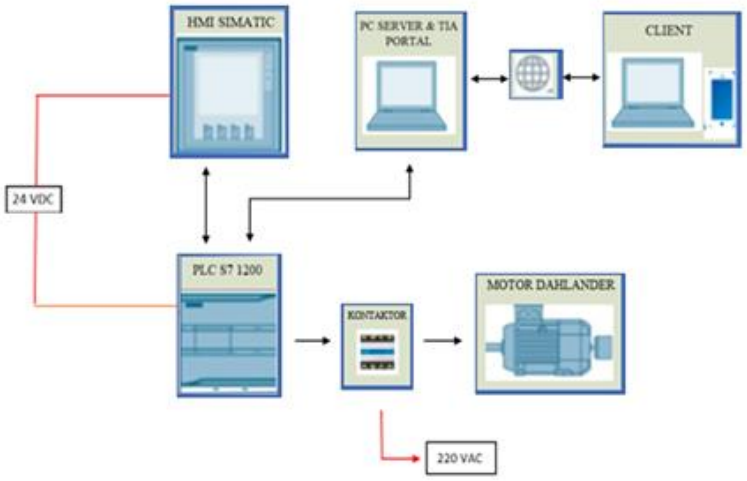


Figure 1. System block diagram

Based on Figure 1, it can be seen that the block diagram of the two-speed Dahlander motor control system using a PLC based on HMI and IoT illustrates the integration of hardware and software to control both high and low motor speeds. The SIMATIC S7-1200 PLC serves as the central unit for processing input-output data as well as the main controller of the system [13]-[15]. System visualization and control can be carried out through two interfaces, namely the SIMATIC HMI and a smartphone connected via a web server, both interfaces function to display and send instructions to the PLC [16]-[18]. The system is programmed via a PC using the TIA Portal application. The Dahlander motor used is a three-phase induction motor with two speed levels that can be controlled through the PLC [19]. To activate or disconnect the motor circuit, contactors are used, which operate based on electromagnetic principles and are automatically controlled by the system. This study is implemented on a 1.3 kW Dahlander motor. The working principle of the Dahlander motor control system proposed in this study is explained in Figure 2 below.

Figrure 2. Flowchart system

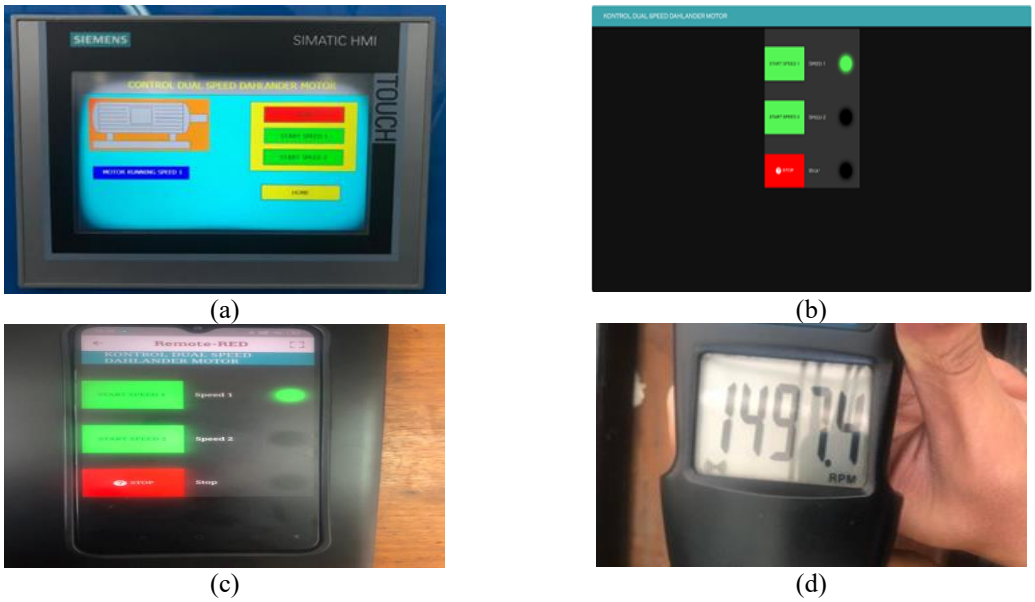
Figure 2 explains the working principle of the Dahlander motor speed control system that utilizes HMI-based PLC and IoT via a web server. This system allows control of two motor speed modes, slow (speed 1) and fast (speed 2) which are programmed via TIA Portal software for PLC and HMI, and Node-RED for IoT implementation. The initial flowchart interface displays the main menu button as access to motor control. In the control display, the user can select speed 1 mode (slow rotation with Delta configuration) or speed 2 (fast rotation with Star configuration), and the motor will operate according to the selected mode until the stop button is pressed to stop the motor.

3. RESULTS AND DISCUSSION

The dahlander motor control system using PLC based on HMI and IoT in this study was tested through a trainer in the laboratory. To see the speed of the motor controlled via the HMI screen, PC Client and Smartphone were measured using a speed measuring instrument, namely a tachometer. The system test series can be seen in Figure 3 below.

Figure 3. Setup of the Dahlander motor control system using a PLC based on HMI and IoT

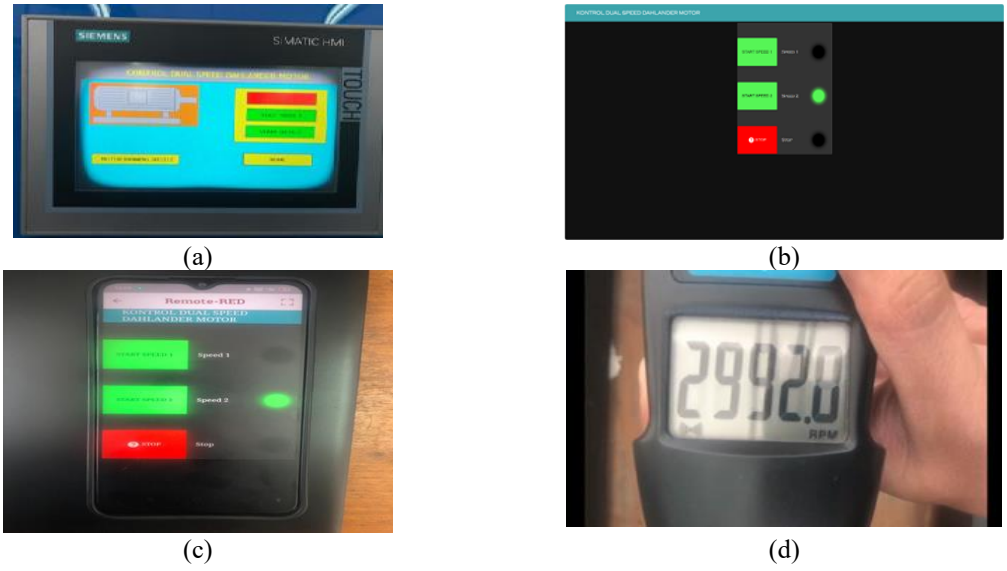
Testing of the slow and fast rotation control system on the dahlander motor is done by changing the circuit shape on the contactor. To be able to run the motor at a slow rotation speed, the circuit shape used is a delta connection (Δ), while for a fast rotation speed, the circuit shape used is a star-star connection (YY). The first test was carried out at a slow rotation speed and the circuit shape used was a delta connection (Δ). The results of the 1 pat test are seen in Figure 4 below.



(a) (b) (c) (d)

Figure 4. Test 1 (a) HMI, (b) PC, (c) Smartphone, (d) Tachometer

Based on Figure 4, the test results show that test 1 using the speed 1 indicator shows that the motor can be operated via the HMI screen, PC client and smartphone. Where by pressing the start speed 1 button on one of the interfaces, the motor will operate at slow speed and the motor running speed 1 indicator will appear on the HMI screen, meaning that the motor at speed 1 is operating, for the PC client and smartphone the speed 1 indicator will light up simultaneously, for this test the motor speed read through the tachometer is 1497 rpm. Furthermore, the second test is carried out, namely for this control system, it is carried out at a fast rotation speed. In the fast rotation system, the form of the circuit used is a star-star (YY) connection which in the test uses the speed 2 indicator, the results of the second test can be seen in Figure 5 below.



(a) (b) (c) (d)

Figure 5. Test 2 (a) HMI, (b) PC, (c) Smartphone, (d) Tachometer

Based on Figure 5, it can be seen that the motor can be operated via the HMI screen, PC client and smartphone. For PC client and smartphone in the second test, both use node-red software. By pressing the start speed 2 button on one of the interfaces, the motor will operate at high speed and the motor running speed 2 indicator will appear on the HMI screen, meaning the motor at speed 2 is operating, for PC client and smartphone the speed 2 indicator will light up simultaneously, for this test the motor speed read by the tachometer is 2992 rpm.

4. CONCLUSION

This study successfully designed and implemented a two-speed control system for Dahlander motors based on Siemens S7-1200 PLC integrated with HMI interface (KTP700 Comfort) and IoT platform using Node-RED. The developed system is able to automatically control the motor in two speed modes of slow rotation with delta configuration (Δ) and fast rotation with star-star configuration (YY) through various interfaces such as HMI, PC, and smartphone. The test results show that the system can operate stably and accurately, with measured speeds of 1497 rpm for speed 1 and 2992 rpm for speed 2, respectively. The use of TIA Portal simplifies PLC programming and HMI design, while Node-RED provides flexibility in implementing web-based IoT interfaces. The integration of this automation technology not only improves system efficiency and reliability, but also enables real-time remote control, making it very suitable for application in small and medium industries in supporting the transformation towards Industry 4.0.

REFERENCES

[1] T. Đuran, S. Tvorić and V. Šimović, "Comparison of Efficiency Level for Induction Motor with Dahlander Winding in Direct on Line and via Frequency Converter Drive Connection," *2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO)*, Opatija, Croatia, 2022, pp. 142-146, doi: 10.23919/MIPRO55190.2022.9803791.

[2] S. A. Saputro, Asmar, and W. Sunanda, "Energy needs in dynamic braking on Dahlander motor," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Nov. 2020. doi: 10.1088/1755-1315/599/1/012007.

[3] Risfendra, Yoga Maulana Putra, H. Setyawan, and M. Yuhendri, "Development of Outseal PLC-Based HMI as Learning Training Kits for Programmed Control Systems Subject in Vocational Schools," in *5th Vocational Education International Conference*, 2023.

[4] I. M. dos Santos, R. B. Tavares, and A. M. Tavares, "Transformação de um Motor de Indução Trifásico em um Motor Dahlander para Ensino e Pesquisa," *Sociedade Brasileira de Automatica*, Dec. 2020. doi: 10.48011/asba.v2i1.1020.

[5] R. Jannah and M. Yuhendri, "Pembuatan Jobsheet Kendali Motor Induksi menggunakan Human Machine Interface," *J. Pendidik. Tek. Elektro*, vol. 3, no. 2, pp. 184–191, 2022.

[6] D. B. Durocher, M. R. Hussey, D. E. Belzner and L. Rizzi, "Application of Next-Generation Motor Management Relays Improves System Reliability in Process Industries," in *IEEE Transactions on Industry Applications*, vol. 55, no. 2, pp. 2121-2129, March-April 2019, doi: 10.1109/TIA.2018.2879468.

[7] R. Muhammad and M. Yuhendri, "Variable speed control of DC motor using four quadrant controlled rectifier based on Human Machine Interface," *J. Ind. Autom. Electr. Eng.*, vol. 01, no. 01, pp. 229–235, 2024

[8] C. Ferrater-Simon, L. Molas-Balada, O. Gomis-Bellmunt, N. Lorenzo-Martinez, O. Bayo-Puxan and R. Villafafila-Robles, "A Remote Laboratory Platform for Electrical Drive Control Using Programmable Logic Controllers," in *IEEE Transactions on Education*, vol. 52, no. 3, pp. 425-435, Aug. 2009, doi: 10.1109/TE.2008.930095.

[9] J. Xu, B. Gu, and G. Tian, "Review of agricultural IoT technology," Jan. 01, 2022, *KeAi Communications Co.* doi: 10.1016/j.aiia.2022.01.001.

[10] I. Rifaldo and M. Yuhendri, "Sistem Monitoring Kecepatan Motor Induksi dengan HMI Berbasis PLC," *JTEIN J. Tek. Elektro Indones.*, vol. 3, no. 2, pp. 319–325, 2022.

[11] F. Hanifah and M. Yuhendri, "Kontrol dan Monitoring Kecepatan Motor Induksi Berbasis Internet of Things," *JTEIN J. Tek. Elektro Indones.*, vol. 4, no. 2, pp. 519–528, 2023.

[12] F. Ghoroghchian, A. D. Aliabad and E. Amiri, "Dual-Pole LSPM Motor with Dahlander Winding for High Inertia Loads," *2019 IEEE 28th International Symposium on Industrial Electronics (ISIE)*, Vancouver, BC, Canada, 2019, pp. 308-312, doi: 10.1109/ISIE.2019.8781490.

[13] N. Subhashini, M. Mouli, J. Mugunthan, R. P. Kumar, M. Revanth and M. Tejaa, "Automated Induction Motor Monitoring System Using IoT," *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)*, Coimbatore, India, 2023, pp. 166-169, doi: 10.1109/ICACCS57279.2023.10112942.

[14] E. Noyjeen, C. Tanita, N. Panthasarn, P. Chansri and J. Pukkham, "Monitoring Parameters of Three-Phase Induction Motor Using IoT," *2021 9th International Electrical Engineering Congress (iEECON)*, Pattaya, Thailand, 2021, pp. 483-486, doi: 10.1109/iEECON51072.2021.9440368.

[15] N. Dehbashi, M. SeyyedHosseini and A. Yazdian-Varjani, "IoT Based Condition Monitoring and Control of Induction Motor Using Raspberry Pi," *2022 13th Power Electronics, Drive Systems, and Technologies Conference (PEDSTC)*, Tehran, Iran, Islamic Republic of, 2022, pp. 134-138, doi: 10.1109/PEDSTC53976.2022.9767328.

[16] A. Tanjung, "Analisis Penggunaan Energi Listrik Motor Induksi Tiga Phasa Menggunakan Variable Speed Drive (VSD)," *Jurnal Sain, Energi, Teknologi & Industri)*, vol. 2, no. 2, pp. 52–59, 2018.

[17] U. Syarah and M. Yuhendri, "Constant Torque Control of Induction Motor Using Variable Frequency Drive Based on Internet of Things," *J. Ind. Autom. Electr. Eng.*, vol. 1, no. 1, pp. 7–12, 2024.

[18] Y. A. Putra and M. Yuhendri, "Smart Monitoring Pompa Air Otomatis Berbasis Human Machine Interface Dan Internet Of Things," *JTEIN J. Tek. Elektro Indones.*, vol. 4, no. 2, pp. 863–876, 2023.

[19] S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A Literature Review," *Journal of Computer and Communications*, vol. 03, no. 05, pp. 164–173, 2015, doi: 10.4236/jcc.2015.35021.